Consumer Acceptance of Irradiated Food Products:

An Apple Marketing Study

by

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Abstract

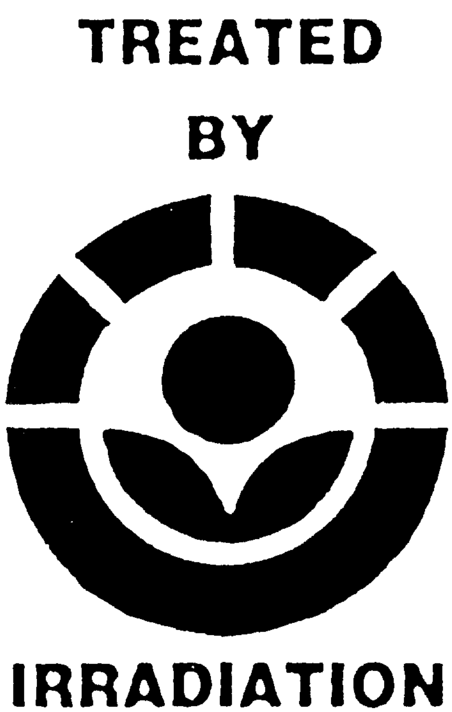
This study was exploratory in nature, with emphasis on initial purchases and not repeat purchases or long-term loyalties to either irradiated or non-irradiated produce. The investigation involved the actual sale of irradiated and non-irradiated apples to consumers. Limited information about the process was provided, and apples were sold at roadside stands. Prices for the irradiated apples were varied while the price for the non-irradiated apples was held constant. Of these 228 West-Central Missouri shoppers, 101 (44%) bought no irradiated apples, 86 (38%) bought only irradiated apples, and 41 (18%) bought some of both types. Results of probit regressions indicated three significant independent variables. There was an inverse relationship between the price of irradiated apples and the probability of purchasing irradiated apples. There was a positive relationship between the purchasers' educational level and the probability of purchasing irradiated apples. Predicted probabilities for belonging to categories in probit models were computed. Depending on particular equation specification, correctly placed were approximately 70 percent of the purchasers of the two categories--bought only non-irradiated apples, or bought some of both irradiated and non-irradiated apples or only irradiated apples. This study suggests that consumers may be interested in food irradiation as a possible alternative or supplement to current preservation techniques.

Introduction

Food irradiation is a process that utilizes ionizing radiation to physically affect and interact with the atoms and molecules making up foods and food contaminants, causing chemical and biological consequences which can be beneficial (Urbain). The use of food irradiation, a technology existing for more than 40 years, as a post-harvest preservation technique in the United States has been slow to develop. Until 1986, commercial use of food irradiation was hampered by the lack of U.S. Food and Drug Administration (FDA) approval. However, on April 18, 1986, ionizing radiation applications were expanded to include treatment of fresh fruits and vegetables at doses up to 100 kilorads (Food and Drug Administration). At this time, the Food and Drug Administration required that all irradiated food products sold in retail packages be labeled with the international irradiation (radura) symbol and the statement, "treated by irradiation" or "treated with radiation" (Figure 1). The statement may also describe the type of radiation used, as well as its purpose, e.g., "treated with gamma radiation to extend shelf life." Additional information, such as "this treatment does not induce radioactivity," may also be included for educational purposes. If the product contains ingredients that have been irradiated, the symbol and statement need not appear.

Figure 1

International Symbol for Irradiated Foods: Additional Wording Required by the Food and Drug Administration



Recent proposals to approve food irradiation have generated public debate about the wisdom, safety, and overall acceptability of the process as an appropriate alternative to current food preservation methods. Areas of concern include effects of unique radiolytic products created when foods are irradiated, reduction in the quantity of food nutrients, increased highway transportation of radioactive materials, disposal of radioactive wastes, and worker safety in irradiation facilities (Bruhn, Schutz, and Sommer; Terry and Tabor; Tilley and Falk; Urbain). Because of recent nuclear accidents (Three Mile Island, Chernobyl), U.S. consumers are concerned as to the wisdom of using radioactive matter to "enhance" food quality. However, possible benefits of the process include extended shelf life, replacement of less safe chemical fumigants, safe transport of products from insect quarantine, and improved sanitation of food.

Consumers have indicated that they are not comfortable with herbicides, insecticides, chemical sprays, and preservatives used on their foods. Of the few studies conducted on acceptance of food irradiation, data indicate that acceptance for some consumers would depend upon actions taken to convince them of the safety of this relatively new process (Bruhn, Schutz, and Sommer; Terry and Tabor; Urbain).

Irradiation technology will not solve all the problems of post-harvest deterioration of highly perishable fresh produce. However, it should be viewed as another form of processing and storage--a possible supplement to refrigeration and other post-harvest technology procedures aimed at reducing post-harvest losses. Post-harvest treatments of fresh fruits and vegetables, which are living tissue, are designed to slow down their respiration rates without terminating their living status. Fresh fruits and vegetables which are relatively tolerant of ionizing-radiation stress at doses less than 100 kilorads include apples, cherries, nectarines, peaches, raspberries, strawberries, and tomatoes (Kader).

Objectives

Limited numbers of related studies in the area of consumer demand for irradiated foods exist. The research reported here is exploratory in that it centers on West-Central Missouri's consumer acceptance of the irradiation concept as measured by the willingness to purchase irradiated produce. Specific objectives are to:

1) estimate the percent of consumers willing to purchase irradiated produce,

2) examine the differential pricing effects irradiated produce has upon consumer demand, and

3) observe the impacts of various socioeconomic characteristics on the demand for irradiated produce.

Methodology

Results from other studies indicate that consumers were wary of irradiated foods, but did respond positively to educational information (Bruhn, Schutz, and Sommer; Terry and Tabor; Urbain). Often, consumers were unable to interpret correctly the irradiation logo, and there appeared to be doubt that consumers would follow through on their commitment to purchase irradiated products. This study addresses consumers' willingness to actually purchase irradiated produce. A retailing experiment utilizing irradiated and non-irradiated apples was conducted in an attempt to achieve stated objectives.

Data collection was initiated in May 1988 after 1,200 pounds of Washington Red Delicious apples (extra fancy) were bought in West Memphis, Arkansas. Since the irradiation facility nearest Kansas City is located in West Memphis, apples were purchased from local wholesalers, with only a portion of the apples being irradiated. Doses ranged between 57 and 99 kilorads. With the exception of the irradiation treatment, both groups of apples were transported and stored in a traditional manner.

Independent supermarkets and chain stores are reluctant to take the initiative in displaying irradiated foods. Morrison states:

> Companies are reluctant to risk the reputation of their brand names by associating them with the process . . . Opponents of the process say that safety has not been proven, and they have threatened to boycott future sales of irradiated foods.

To avoid negative impacts on independent supermarkets and chain stores, open air markets were selected as marketing centers. It was hoped that this type of market would also lead to avoidance of any possible organized consumer protests which might bias the study significantly. Open market stands were stationed at three different sites, with each of the three displays operating four consecutive days (Thursday through Sunday) for two weeks. Both irradiated and non-irradiated apples were given equal prominence, with each irradiated apple carrying the irradiation logo. Limited information about the irradiation process was provided. This information included benefits and costs (both dollar and non-dollar), as well as safety issues. Samples of both irradiated and non-irradiated apples were offered to each customer. Customers were encouraged to smell, feel, and taste the samples. Price per pound of the irradiated apples was randomly varied among $0.29, $0.39, and $0.49, while the price of non-irradiated apples was held constant at $0.39. Each sale of apples was weighed and recorded; prices of irradiated apples were noted. Also, immediately after making their purchases, customers were asked to answer fourteen questions addressing socioeconomic variables and reasons for purchasing particular apples.

The dichotomous nature of the dependent variable--consumers' preferences for irradiated or non-irradiated apples--required that a binary choice model be used. Although ordinary least squares regression can be used to estimate a binary choice model (i.e., a linear probability model), it has at least two statistical drawbacks which make it inappropriate in this situation. First, the error term in a linear probability model is heteroscedastic--that is, the variance of the error term is not constant across observations--making the test of a coefficient's statistical significance nonsensical. Second, the estimated coefficients in the linear probability model can lead to predicted values of the dependent variable that are outside of the 0-1 boundaries (Pindyck and Rubinfeld).

Since the dependent variable was qualitative, logit or probit regression could be used. The probit formulation was selected because it assumes that an observable and measured dependent variable is an ordinal scale of an underlying unobservable and unmeasured variable. Underlying variables are assumed to be functions of observed independent variables. Coefficients obtained from estimating probit equations pertain to probabilities of observing the higher category of the dependent variable (Eastwood, Brooker, and Orr; Aldrich and Nelson; McKelvey and Zavoina).

Survey Results

Information from 228 usable surveys was evaluated. Purchasers included 129 females, with all but nine shoppers being caucasian. Of these 228 shoppers, 101 (44%) bought no irradiated apples, 86 (38%) bought only irradiated apples, and 41 (18%) bought some of both types. The average shopper purchase was 3.84 pounds of apples. Individuals purchasing both irradiated and non-irradiated apples, bought 2.08 pounds of irradiated and 2.27 pounds of non-irradiated apples. Table 1 demonstrates that 56 percent of all shoppers purchased at least some irradiated apples, while 44 percent chose only the non-irradiated product. When faced with equal prices ($0.39 per pound for irradiated and non-irradiated apples), approximately one-third of the buyers purchased only non-irradiated, one third purchased only irradiated, and one third purchased some of both types. When the price of irradiated apples was lower ($0.29 versus $0.39 for non-irradiated), the vast majority purchased only irradiated apples. The inverse was true when irradiated apples were priced $0.10 higher than the non-irradiated product. Thus, it appears that price is driving the consumer's decision on whether to purchase irradiated versus non-irradiated apples.

After purchasing apples, shoppers were asked to evaluate various apple attributes (Table 2). In terms of overall quality, almost one-third of the responding buyers felt the irradiated apples were superior, while only 7.7 percent thought the overall quality was inferior. Consumers found little difference between irradiated and non-irradiated apples in terms of appearance and color, as 78.4 and 79.2 percent, respectively, rated the two characteristics equal. Approximately two-thirds of all responding shoppers viewed apple firmness and freshness as being essentially equivalent, while slightly more than one in four thought these attributes were preferable in the irradiated apples.

The greatest difference of opinion was noticed in the taste attribute. While 31.1 percent thought taste of irradiated apples was superior, 15.9 percent preferred the taste of the non-irradiated product. A more detailed examination of the taste data revealed a striking difference between those buying and not buying irradiated apples. Of those shoppers selecting only non-irradiated apples, only 43.6 percent chose to taste samples of the irradiated apples. However, 70.1 percent buying irradiated apples tasted these samples before deciding to include them in their purchases. Of all shoppers tasting irradiated apple samples, 66.9 percent proceeded to purchase the irradiated produce.

As seen by shoppers' comments listed in Table 3, taste appeared to be a primary concern. Fourteen shoppers purchasing only non-irradiated apples commented that the non-irradiated apples tasted better, while 20 shoppers purchasing only irradiated apples stated that the irradiated apples tasted better. Twenty of the 179 comments dealt with the lack of knowledge about the process or concerns for food safety. Eighteen of the buyers of irradiated apples viewed extended shelf life as a value-added attribute in apples, while five saw extended shelf live as adding no value. Of the 97 comments made by those shoppers buying at least some irradiated produce, 40 considered the apples to be a novelty, a curiosity, or a chance to conduct

Table 1

Percent of All Consumers Purchasing Only Non-irradiated Apples, Some of Both Types of Apples, or Only Irradiated Apples: Sorted by Price Per Pound of Irradiated Apples

Price Per Pound of Irradiated Apples	Percent of All Consumers Purchasing		
	Non-irradiated Apples Only	Some of Both Types of Apples	Irradiated Apples Only
$.29	10	3	20
$.39	12	10	12
$.49	22	5	6
Total Percentages	44	18	38

Table 2

Shoppers' Comparisons and Evaluations of Irradiated Apple Attributes Versus Non-irradiated Attributes

Response	Percent
Overall Quality	
Worse	7.7
Same	57.0
Better	31.0
Do Not Know	4.2
Appearance	
Worse	2.8
Same	78.4
Better	17.6
Do Not Know	1.1
Freshness	
Worse	3.0
Same	63.7
Better	26.7
Do Not Know	6.7

Response	Percent
Taste	
Worse	15.9
Same	47.8
Better	31.1
Do Not Know	5.1
Firmness	
Worse	7.2
Same	62.5
Better	25.7
Do Not Know	4.6
Color	
Worse	4.2
Same	79.2
Better	15.5
Do Not Know	1.2

Note: Due to rounding error, totals do not always sum to 100.0 percent.

Table 3

Shoppers' Comments about Apple Purchases

Comment	Frequency
Purchased no irradiated apples	
Non-irradiated apples taste better	14
Irradiated apples are not good for you/not safe	10
Do not know enough about irradiation/had not heard of irradiation	10
Irradiated apples are more expensive	10
Want them as natural as possible	6
Extended life of apples is not necessary, as consumption will be immediate	5
Do not want anything added to, or done to the apples (want natural/organically grown apples)	5
Do not want anything to do with irradiation	4
Do not see any benefits in irradiation	3
Do not want any chemicals in my body	3
Food irradiation does not sound appealing	3
Do not want irradiated produce because I prefer fresh	2
Non-irradiated apples look better	2
Am comfortable with current apples and feel there was no need for irradiation	2
Irradiation is a marketing gimmick only	1
Think non-irradiated apples are healthier	1
Irradiation is a new concept, and I preferred to wait a while before trying	1
Purchased both irradiated and non-irradiated apples	
Want to try them both (no specific reasons other than curious)	13
Want to compare apples for shelf life and other quality attributes	12
Makes no difference to me	1
Purchased only irradiated apples	
Irradiated apples taste better	20
Feel irradiated apples will last longer	18
Irradiation is new (treated as a novelty)	15
Irradiated apples are less expensive	13
Think irradiation is a good idea	2
Think irradiated apples are safer	1
Know about the benefits of food irradiation and am convinced of its benefits	1
Think there would be fewer chemical additives	1

their own experiments on extended shelf life. The variation in the price of the irradiated apples was an important factor, with 23 shoppers indicating its impact on their selections.

Probit Model Results

Table 4 describes the fifteen variables included initially in the probit model. Results of the estimate of the initial probit model are presented in Table 5. Asymptotic t-ratios were used to determine the significance of each coefficient. Four measures of overall fit were used to assess the equation. These measures were 1) the log likelihood value, 2) the chi square as conventionally calculated, 3) McFadden R^2, and 4) the percent of the sample correctly predicted. Actual buyer categories were compared to the predicted categories, and the percent correctly predicted was calculated.

Previous studies had found that income, age, education, sex, and race were associated with significantly different consumption of specific food items, but not every category was significantly different (Adrian and Daniel; Raunikar, Huang, and Purcell; Eastwood, Brooker, and Orr; Scearce and Jensen; Smallwood and Blaylock, 1984; Smallwood and Blaylock, 1981). One survey of attitudes about irradiated produce found sex and income variables significant, but explanatory power of the model was low (Terry and Tabor). Due to little prior research of irradiated produce demand, signs of independent variables were not hypothesized in this study. There is also no a priori basis for determining which variables to include in the estimated equations. Consequently, an initial probit equation was calculated using all independent variables contained in Table 4. The X^2 value for the initial probit model (Table 5) was significant at 42.37. The X^2 value was interpreted as an F-test and affords an evaluation of the significance of the initial probit model. The independent variable, price, was significant at the .01 level and was found to be inversely related to customer purchase of irradiated apples. However, the variable ED3, customers who attended college or graduated, is positive and significant. It appears that shoppers having attended college have a higher probability of purchasing irradiated produce than shoppers having lesser amounts of formal education. None of the remaining independent variables included in the regression analysis had a significant effect. The overall probit model accounted for 14 percent of the total variation present while correctly predicting 70 percent of buyers' decisions to purchase or not purchase irradiated apples. Consistent with the reviewed literature, many of the coefficients had insignificant asymptotic t-values. One possibility was that the insignificance of some coefficients was due to collinearity among the independent variables.

Results obtained from the initial computer run were used to delete variables from subsequent regressions using the following criteria (similar to that used by Eastwood, Brooker, and Orr). The reduction of pretest bias in further estimations, necessitated that an orderly procedure be implemented. Variables whose asymptotic t-values were small in absolute value were omitted and a new probit equation estimated. Coefficients in the new equation were compared to their initial counterparts to determine whether there were large changes in estimated values. If this occurred, multicollinearity was suspected, and the corresponding variable was reintroduced.

A final statistical test was employed for each model. Once a model was obtained which included all the significant variables, adjusted for multicollinearity as noted above, a nested hypothesis test was performed. The null hypothesis was that the omitted variables had coefficients of zero, and likelihood ratio tests were conducted. The results were consistent with using the reduced model which is described in Table 6. The chi square value remained significant, with the model explaining 12 percent of the total variation and correctly grouping individuals 70 percent of the time. Price continued to be significant and inversely related to shopper purchase of irradiated produce. All of the included education categories were significant. The interpretation was that relative to the lowest educational attainment group, a more highly educated shopper revealed a greater probability of purchasing the irradiated produce.

Table 4

Variables Included in the Initial Probit Model

Variable	Measurement	Frequency
BUY	= 0 if shopper purchased no irradiated apples = 1 if shopper purchased irradiated apples	101 127
PRICEIRR	= price per pound charged for irradiated apples	39.1[a]
AGE	= age of the shopper	36.7[b]
HHSIZE	= the number of persons residing in the household	2.6[c]
RACE	= 1 if the shopper is a member of the white race; = 0 otherwise	219
SEX	= 1 if the shopper is female; = 0 otherwise	129
	Educational Level Attained by the Shopper	
ED1	= 1 if less than high school diploma; = 0 otherwise (omitted category)	46
ED2	= 1 if high school diploma; = 0 otherwise	65
ED3	= 1 if attended college or graduated; = 0 otherwise	117
	Total Household Income	
INC1	= 1 if \$0 - \$19,999; = 0 otherwise (omitted category)	100
INC2	= 1 if \$20,000 - \$39,999; = 0 otherwise	68
INC3	= 1 if \$40,000 or more; = 0 otherwise	60
	Political Party Preference of the Shopper	
INDEP	= 1 if preference was neither democrat nor republican; = 0 otherwise (omitted category)	108
REPUB	= 1 if preference was republican; = 0 otherwise	64
DEMOC	= 1 if preference was democrat; = 0 otherwise	56

[a] Average price in cents per pound.

[b] Average age of shopper rather than frequency.

[c] Average household size rather than frequency.

Summary

This study was exploratory in nature, with emphasis on initial purchases and not repeat purchases or long-term loyalties to either irradiated or non-irradiated produce. The study involved the actual sale of irradiated and non-irradiated apples to consumers at roadside stands. Limited information about the process was provided, and prices for the irradiated apples were varied, while the price for the non-irradiated apples was held constant.

Many shoppers appear willing to purchase irradiated products even when they are provided only limited information about food irradiation. When the prices of irradiated and non-irradiated apples were identical, consumers purchased almost equal amounts of both types. In some cases this behavior may have been due to curiosity or the novelty of the product, but in any case a willingness to purchase was demonstrated. In addition, some consumers viewed extended shelf life of apples, an already semi-storable product, as a definite advantage.

Among purchasers of only non-irradiated apples, the single most common reason cited for doing so was better taste (17%). Apprehension about irradiated products definitely was an important part of shoppers' refusal to purchase irradiated produce. Of all commenting shoppers not purchasing irradiated apples, 29.3 percent cited safety concerns or a lack of knowledge about the process and the product.

Among commenting customers purchasing only irradiated apples, 28 percent perceived that irradiated apples tasted better. Although the longer shelf life of the irradiated apples was also perceived as a positive attribute, as 18.8 percent cited this as their major reason to purchase, this attribute may not be as important in apples as with more perishable produce. Therefore, it is entirely possible (although not directly ascertained during this study) that a larger percentage of consumers would be willing to pay a higher price for other irradiated produce, if such customers were convinced that shelf life would be significantly extended.

Table 5

Purchasing Irradiated Apples:
Initial Probit Regression Results

Independent Variables	Coefficients
Constant	1.865*[a]
	(2.47)[c]
PRICEIRR	-0.049**[b]
	(4.45)
AGE	-.004
	(.72)
HHSIZE	.031
	(.48)
SEX	-.049
	(.26)
ED2	.454
	(1.45)
ED3	.784**
	(2.66)
RACE	-.378
	(.69)
INC2	.157
	(.66)
INC3	.128
	(.49)
DEMOC	.274
	(1.21)
REPUB	.150
	(.70)
Log likelihood	-135.37
X^2	42.37**
McFadden R^2	.14
Percent predicted correctly	70

[a]* Significant at the .05 level.

[b]** Significant at the .01 level.

[c] Asymptotic t-values are shown in parentheses.

Table 6

Purchasing Irradiated Apples:
Reduced Probit Regression Results

Independent Variables	Coefficient
Constant	1.500**a (3.22)c
PRICEIRR	-.049** (4.51)
ED2	.480*b (1.98)
ED3	.877** (3.82)
Log likelihood	-137.23
X^2	38.64**
McFadden R^2	.12
Percent predicted correctly	70

[a]* Significant at the .05 level.

[b]** Significant at the .01 level.

[c] Asymptotic t-values are shown in parentheses.

Results of probit regressions indicated three significant independent variables. There was an inverse relationship between the price of irradiated apples and the probability of purchasing irradiated apples. There was a positive relationship between the purchasers' educational level and the probability of purchasing irradiated apples. Depending on particular equation specification, correctly placed were approximately 70 percent of the purchasers of the two categories--bought only non-irradiated apples, or bought some of both irradiated and non-irradiated apples or only irradiated apples. The estimated McFadden R^2 was approximately .14.

Implications

Much additional research on consumer acceptance of the irradiation process is needed. Currently, few irradiated products are available to the consumer. The exception is the use of irradiated products, such as spices, as ingredients in processed food. As in the case of other new food preservation techniques, educational programs promoting the benefits gained from irradiating produce will be needed. The process will not be a solution to all food preservation problems, but could find niches in food product marketing where taste is not adversely affected but shelf live is extended. If additional chemical and preservative additives are restricted or banned, there is the possibility that food irradiation could be used as a viable alternative. Whether large quantities of irradiated produce will ever be commercially accepted will depend on the shoppers' willingness to accept the irradiation process. This study indicates that a substantial proportion of consumers might be interested in food irradiation as a possible alternative or supplement to current preservation techniques.

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